# IN THE US PATENT AND TRADEMARK OFFICE

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| Application Number: | Not yet assigned |
| Filing Date: | Filed herewith |
| Applicant: | Robert E. Fontana et al. |
| Application Title: | Fully Undercut Resist Systems Using E-Beam Lithography for The Fabrication of High Resolution MR Sensors |
| Examiner: | Not yet assigned |
| Art Unit: | Not yet assigned |

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, DC 20231, on 5/10/01.

date of deposit

Tiantina Gu

Name of Person Signing

5/10/01

date

## PRELIMINARY AMENDMENT

Commissioner of Patents and Trademarks
Washington, DC 20231

Sir:

Prior to examination, kindly amend the above application as follows:

**SPECIFICATION:**

Kindly replace the "Brief Description of The Figures" section and indicated paragraphs of the specification with the amended version below. A marked-up version of the "Brief Description of The Figures" section and the indicated paragraphs is attached on separate pages.

Page 3, line 23 through page 4, line 8:

Undercut bilayer resist systems of the type depicted in Figs. 1a-1e can be fabricated using e-beam lithography rather than photolithography. The present sensor trackwidths of 0.3 micron are already beginning to push the resolution limits of I-line photolithography. Fundamental constraints such as the diffraction limit of light make photolithographically patterning sub-0.2 micron TW sensors with I-line radiation practically impossible. Electron beam lithography has no such resolution limits, which make it an attractive (but by no means the only) choice for patterning ultra-narrow trackwidth MR sensors. Figs. 2a-2b are schematic diagrams illustrating the top and side views of a bilayer resist pedestal using an e-beam resist chemistry technique. An e-beam sensitive image resist layer **206** is deposited on a resist layer **204**, which cannot be seen in Fig. 2a. The open regions **202** on the image resist layer **206** are formed by exposing those regions to an electron beam and then dissolving the exposed resist in a suitable developer. The undercut is then formed by using an appropriate developer to dissolve the bottom resist layer, where the undercut distance is determined by the develop time.

Page 8, line 26 through page 9, line 16:

## BRIEF DESCRIPTION OF THE FIGURES

Figs. **1a-e** are schematic diagrams illustrating the steps of a process of fabricating MR sensors using a bilayer resist pedestal technique of the prior art;

Figs. **2a-b** are schematic diagrams showing top and side views of a bilayer resist pedestal structure of the prior art;

Figs. **3a-b** are schematic diagram showing top and side views of a bilayer fully undercut resist structure according to a preferred embodiment of the present invention;

Figs. **4a-d** are schematic diagrams illustrating the steps of a process of making the bilayer fully undercut resist structure shown in Figs. 3a-b;

Figs. **5a-e** are schematic diagrams illustrating the steps of a process of fabricating a GMR sensor using the fully undercut resist bridge illustrated in Figs. 4a-d;

Figs. **6a-f** are schematic diagrams illustrating the steps of a process of fabricating a MTJ sensor using the fully undercut resist structure illustrated in Figs. 4a-d;

Fig. **7** is a TEM cross-section of a GMR sensor fabricated using the process described in Figs. 5a-e;

Fig. **8** is a cross-sectional schematic diagram of a MR read head including the MR sensor illustrated in Figs. 5a-e and 6a-e; and

Fig. **9** is a schematic diagram illustrating a disk drive including the MR read head of Fig. 8.

<u>Page 12, line 33 through page 13, line 21:</u>

The fully undercut resist bridge formed by the process described in Figs. 4a-4d may also be used for fabricating MTJ sensors. Figs. 6a-6f illustrate a process for fabricating a MTJ sensor using a fully undercut resist bridge. As shown in Fig. 6a, a fully undercut resist bridge **600** is positioned on top of a MTJ layer structure **602**. Ion beam milling on the MTJ layer structure **602** defines an MTJ sensor **601** with trackwidth equal to the width of the bridge **600** (TW) as shown in Fig. 6b. Insulating layers **604** are deposited adjacent to the MTJ sensor **601** before hard bias layers **606** are deposited to form the longitudinal bias for MTJ sensor **601**, as shown in Fig. 6d. Insulating layers **604** provide electrical insulation between the hard bias layers **606** and the MTJ sensor **601**. Other insulating layers **608** are deposited on the hard bias layers **606** to electrically insulate the hard bias layers from leads that are deposited in a separate process, which is not shown in Fig. 6. Finally, the resist bridge **600** is removed via liftoff processing from the MTJ sensor **601** as shown in Fig. 6f. As shown in Figs. 6c-6e, a quantity of hard bias material **606'** and insulating material **604'** and **608'** is also deposited onto the top and sidewalls of resist bridge **600**. However, this material is removed along with the resist layer **600** in a liftoff process described in Fig. 6f.

**REMARK**

This preliminary amendment is being filed concurrently with the present application. No new matter is entered.

Respectfully submitted,

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**MARKED-UP AMENDED SPECIFICATION**

Page 3, line 23 through page 4, line 8:

Undercut bilayer resist systems of the type depicted in Figs. 1a-1**[d]**e can be fabricated using e-beam lithography rather than photolithography. The present sensor trackwidths of 0.3 micron are already beginning to push the resolution limits of I-line photolithography. Fundamental constraints such as the diffraction limit of light make photolithographically patterning sub-0.2 micron TW sensors with I-line radiation practically impossible. Electron beam lithography has no such resolution limits, which make it an attractive (but by no means the only) choice for patterning ultra-narrow trackwidth MR sensors. Figs. 2a-2b are schematic diagrams illustrating the top and side views of a bilayer resist pedestal using an e-beam resist chemistry technique. An e-beam sensitive image resist layer **206** is deposited on a resist layer **204**, which cannot be seen in Fig. 2a. The open regions **202** on the image resist layer **206** are formed by exposing those regions to an electron beam and then dissolving the exposed resist in a suitable developer. The undercut is then formed by using an appropriate developer to dissolve the bottom resist layer, where the undercut distance is determined by the develop time.

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Figs. **2a-b** are schematic diagrams showing top and side views of a bilayer resist pedestal structure of the prior art;

Figs. **3a-b** are schematic diagram showing top and side views of a bilayer fully undercut resist structure according to a preferred embodiment of the present invention;

Figs. **4a-d** are schematic diagrams illustrating the steps of a process of making the bilayer fully undercut resist structure shown in Figs. 3a-b;

Figs. **5a-e** are schematic diagrams illustrating the steps of a process of fabricating a GMR sensor using the fully undercut resist bridge illustrated in Figs. 4a-d;

Figs. **6a-[e]f** are schematic diagrams illustrating the steps of a process of fabricating a MTJ sensor using the fully undercut resist structure illustrated in Figs. 4a-d;

Fig. **7** is a TEM cross-section of a GMR sensor fabricated using the process described in Figs. 5a-e;

Fig. **8** is a cross-sectional schematic diagram of a MR read head including the MR sensor illustrated in Figs. 5a-e and 6a-e; and

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The fully undercut resist bridge formed by the process described in Figs. 4a-4d may also be used for fabricating MTJ sensors. Figs. 6a-6**[e]**f illustrate a process for fabricating a MTJ sensor using a fully undercut resist bridge. As shown in Fig. 6a, a fully undercut resist bridge **600** is positioned on top of a MTJ layer structure **602**. Ion beam milling on the MTJ layer structure **602** defines an MTJ sensor **601** with trackwidth equal to the width of the bridge **600** (TW) as shown in Fig. 6b. Insulating layers **604** are deposited adjacent to the MTJ sensor **601** before hard bias layers **606** are deposited to form the longitudinal bias for MTJ sensor **601**, as shown in Fig. 6d. Insulating layers **604** provide electrical insulation between the hard bias layers **606** and the MTJ sensor **601**. Other insulating layers **608** are deposited on the hard bias layers **606** to electrically insulate the hard bias layers from leads that are deposited in a separate process, which is not shown in Fig. 6. Finally, the resist bridge **600** is removed via liftoff processing from the MTJ sensor **601** as shown in Fig. 6f. As shown in Figs. 6c-6e, a quantity of hard bias material **606'** and insulating material **604'** and **608'** is also deposited onto the top and sidewalls of resist bridge **600**. However, this material is removed along with the resist layer **600** in a liftoff process described in Fig. 6f.